MSDM Benchmarks from Proton-Induced Reactions on ^{208}Pb at Energy of 1 GeV for the Primary Isotopic Yields

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Isotopic production data of proton-induced reactions with the energy ranges up to GeV are of great importance for understanding the reaction mechanisms of intermediate nuclear reactions. Recently, the precise and voluminous measurements of elements produced from proton-induced spallation reactions with energy ranges from MeV to GeV using several target materials have been carried out due to the interest for spallation neutron source and ADS. These experiments show the isotopic cross section of heavy residuals, and the light residuals are not given. The heavy residual production cross section relied on mass spectrometry and radiochemical methods, which only give the cumulative yields due to long-lived residuals resulting from the short-lived beta decay of the primary reaction products. The development of precise spallation reaction models suffered due to the lack of primary experimental data. It is difficult to systematically compare model calculations with available measured data in order to investigate the physical reasons for the shortcomings of the theoretical models. When T Enqvist at GSI used inverse kinematics by bombarding a liquid-hydrogen target with relativistic heavy ions, the cross sections of the all produced primary residuals from manganese to lead were obtained. In the present work, the Many Stage Dynamical Model (MSDM) developed by Russian scientists is adapted to investigate the primary isotopic product cross section of proton-induced spallation on ^{208}Pb with the energy of 1 GeV. The mass and charge distribution simulations of MSDM with the Fermi-gas level density are 50% larger than the experimental data at the fission peak, lower at spallation part, and two times larger at the region of $50 \leq Z \leq 70$ and $120 \leq A \leq 160$, with the level density of Ignatyuk formula are in good agreement with the experimental data. The primary isotopic production cross sections of fragmentation products from the proton-induced spallation reaction on ^{208}Pb, with proton energy of 1 GeV for elements from manganese to lead are shown, the MSDM calculation results are in good agreement with experimental data. However, the simulations of MSDM code are lower than experimental data for the elements at the side of neutron-rich nuclides from krypton to antimony. The comparison of the MSDM simulations for the spallation products with $Z>65$ and $A>160$ with the measured data is the best, the agreement is shown at the fission fragment with $Z<50$ and $A<120$, at the period of $50 \leq Z \leq 65$ and $120 \leq A \leq 160$, the deviations are shown clearly, the reason is due to the statistical error of the Monte-Carlo calculations.

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